TOPOGRAPHIC ANALYSIS OF CHANGES IN CORNEAL SHAPE AS A FUNCTION OF AGE

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CERTIFICATE

This is to certify Dr.Swarna Udayakumar M.S. Post graduate in Ophthalmology, Regional Institute of Ophthalmology, Government Ophthalmic Hospital attached to Madras Medical College, Chennai, carried out this dissertation titled **"Topographic Analysis of changes in Corneal Shape as a function of Age"** by herself under my guidance and direct supervision during May 2004 to March 2007.

This dissertation is submitted to the Tamilnadu Dr.M.G.R. Medical University, Chennai for the fulfillment of award of M.S Degree in Ophthalmology.

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CONTENTS

INTRODUCTION

Time is the fourth dimension, affecting all things living and nonliving. As time affects the structure of the body, the eye also undergoes certain inevitable consequences. With aging, the ability to maintain physiologic homeostasis under conditions of biologic stress declines. Further this decline is associated with an increase in vulnerability of individual and a decrease in viability potential. Although time and aging are on a continuum they begin at birth.

REVIEW OF LITERATURE

Aging Changes in Corneal dimension

There is a little change in the diametric proportion of cornea from birth till old age. A 2mm growth spurt occurs during the I year of life and after which corneal size remains static at 11.7 mm. Although diameter has been reported to decrease by 0.4 mm after the age of 40 yrs, this change is relatively insignificant and is primarily due to slight central extension of corneoscleral junction.

- Corneal thickness also does not change with aging in central, midperipheral or in the peripheral corneal areas.
- Corneal curvature has been found to change with maturation becoming flatter from birth (7.11 mm) through puberty (8.01mm) and then steepening again thereafter to adult dimensions of 7.08 mm.

- Corneal asphericity likewise progresses from relatively flat centrally at birth to steeper in adults.

- Astigmatism changes from principally with the rule in 92.8% of young patients to against the rule in 85.7% of patients aged 80 yrs .

This change occurs at the same time as eyelid structures are becoming more lax and a relative decease in pressure exerted on the globe has been implicated in age related changes in corneal toricity. Alterations in curvature of cornea can also be induced by non physiological but age related phenomenon such as pterygia.

Cornea as a Refractive Medium

Anatomy

The transparent cornea is the main structure responsible for refraction of light entering the eye. This clear transparent structure forms the anterior 1/6 th of eye ball.

The Cornea Proper

The Cornea has 5 concentric layers

1. The epithelium
2. The acellular Bowman's layer
3. Corneal Stroma

4. Descemets membrane

5. Corneal endothelium

1. Epithelium :- has 3 major functions

- ❖ Acts as a mechanical barrier to foreign material and micro organisms and via the Langerhans cells as an outpost for immune defense.
- ❖ Creates a smooth, transparent optical surface by adsorption of tear film.
- ❖ Maintains a barrier to diffusion of water, solutes and drugs.

Structure :-

- ➢ It is a nonkeratinised stratified squamous epithelium 5-7 layers thick (about 10% of cornealthickness)
- ➢ It has morphologically 3 layers

  a. Single layer of columnar basal cells

  b. 2 to 3 layers of wing cells.

  c. 2 to 3 layers of superficial squamous cells.

Normally only the basal cells replicate, mitosis occurs in about 5% of cells at any one time. The daughter cells move apically and become the overlying wing cells. The daughter cells then migrate anteriorly to become the flattened squamous cells, which ultimately are sloughed into tear film. It takes about 1week for the entire corneal epithelium to be replaced.

Corneal epithelial cells are tightly adherent to each other and the underlying structures by means of specialized junctions. There are three types of junctions,

1 Occluding

2. Communicating

3. Anchoring

At the corneoscleral junction (limbus), the epithelium becomes thicker and may consist of 10 or more layers of cells.

Other than epithelial cells, neurons, melanocytes, Langerhans cells and occasional leucocytes are present within the epithelial layer. Langerhans cells are modified macrophages normally found in the peripheral corneal epithelium. They are thought to play a role in ocular hypersensitivity and other immunological phenomena by processing antigens and presenting them to lymphocytes.

2. **Bowman's membrane** - is an acellular region composed of a network of fine, randomly oriented collagen fibrils. It lies between the epithelial basement membrane and cellular stroma. It is 8-12 μm thick and may help the cornea is maintaining fixed shape there by enabling it to perform its optical function. During embryonic development, this layer develops from basal epithelial cells but these cells lose their ability to regenerate this structure. So once damaged it cannot be regenerated.

3. **Stroma** - Comprises 90% of corneal thickness. It is composed almost entirely of an extracellular matrix with keratocytes dispersed throughout and Type I collagen fibrils running parallel with the surface. It is transparent, fibrous and compact. Keratocytes are the predominant cell type in the stroma. They are flat cells derived from neural crest. Major extracellular material in stroma is collagen, which is highly orderly arranged. Human cornea has 3 different types of collagen (I, V, VI)

4. **Descemets membrane**- It is the normal basement membrane secreted by the corneal endothelium. Its peripheral termination, visible by gonioscopy is known as schwalbe's line It is composed prodominantly type IV collagen and glycoproteins including fibronectin.

Functions:

Forms a scaffold on which the endothelial cells spread themselves .

Acts as a barrier to the penetration of leukocytes and blood vessels into stroma but allows passage of water and small molecules

5. **Corneal endothelium** -The endothelial cells forms a uniform paving stone mosaic of closely apposed polygonal cells with 5-7 sides. These cells are 20 micrometer in diameter with 250 micrometer surface area. The adult human endothelium has

limited capacity to divide and replace aging and injured endothelial cells. Instead the endothelium enlarges, reorganizes, migrates and maintains tight apposition to neighbouring cells.

1. Polymegathism describes heterogeneity in cell size.

2. Pleomorphism describes heterogeneity in cell shape.

With decrease in cell count and increase in cell size and pleomorphism the ability to restore and maintain pump and barrier function is lost.

When cell density < 400-500 cells / sq.mm functional reservoir is minimal and corneal edema is likely to occur.

Functions:- Regulates the passage of aqueous into stroma and helps in maintaining deturgescence.

Refractive Indices of the Eye

Anterior segment structures	**Average**	**Range**
Refractive index		
Air	1.00	
Tear	1.336	
Cornea	1.376	
Corneal epithelium	1.401	
Anterior corneal stroma	1.380	
Posterior corneal stroma	1.373	
Aqueous	1.336	
Lens	1.40	1.38-1.42
Vitreous	1.33	

The tear air interface is the most powerful refracting surface of the eye (80% of the eye's optical power). The curvature of tear film surface reflects that of underlying cornea. The refractive power of cornea is determined by its index of refraction and by its radius of curvature.

The light then undergoes little further refraction till it reaches the lens because the refractive index of aqueous and vitreous are almost the same. At both surfaces of lens , it is refracted. While the refractive index of substance of lens is higher than that of aqueous and vitreous, the difference is not so marked as between that of cornea and air.

Anterior Corneal Curvature - A Prolate

The anterior corneal surface is not exactly spherical since the peripheral part is substantially flatter than the central part. The central part has an average curvature of 7.8mm . The optical zone is nearly spherical but keratometry shows that even in this region curvature varies in different merdians proving the apical zone to be toric . Hence the refractive system of eye has some built - in physiological astigmatism. The central optical zone is that amount of central area varying in power not more than 1diopter difference. The average value is about 4mm .

Astigmatism

Astigmatism is that condition of eye where refraction varies in the different meridians and so a point focus of light cannot be formed upon the retina. Theoretically no eye is stigmatic Astigmatism may be an error of either curvature of cornea or of the lens or of centering.

Curvature astigmatism if any, of high degree has its seat most frequently in the cornea. This anomaly is usually congenital . Its occurrence in a small degree is almost universal. The most common error is about 0.25D with vertical curvature greater than horizontal. This is known as "With the rule astigmatism or physiological astigmatism". This is due to constant pressure of upper lid on the cornea.

As age advances, it disappears or even reverses itself into "Against the rule or inverse astigmatism" with vertical curvature less curved than the horizontal. Curvature astigmatism can also be due to lenticonus, subluxated lens etc.

Optical Condition in Astigmatism

The configuration of rays as it passes through a toric surface is called **strums conoid** with 2 focal lines instead of a single focal point separated by a focal interval. The circle of least diffusion is located dioptrically midway between 2 focal lines. The length of focal interval is the measure of magnitude of astigmatism. This can be corrected by reducing these 2 focal lines into a single focal point onto the retina.

Types of Astigmatism

A. Regular astigmatism: The 2 principal meridians are at right angles to each other. It can be either

- With the rule
- Against the rule

- **Simple myopic or hypermetropic astigmatism:** where one the focal lines falls on the retina. The other may fall either in front as in simple myopic or behind the retina as in simple hypermetropic astigmatism.
- **Compound myopic or hypermetropic astigmatism:** where neither of 2 lines fall on the retina but are placed either in front as is compound myopic or behind the retina as in compound hypermetropic astigmatism.
- **Mixed astigmatism:** where one of focal lines falls in front of retina and the other focal line behind the retina.

B. Irregular astigmatism

Irregularities in the curvature of cornea is different in the various meridians and no geometrical pattern is adhered to.

Evaluation of Corneal Astigmatism

Topography is the science of describing or representing features of a particular place in detail.

History

With the advent of widespread refractive correction at the beginning of 17th century, interest developed in the shape of cornea and the optical properties of eye. Early investigations of corneal topography were confined to gross estimates of corneal curvature.

In 1619, **Scheiner** made the first measurements of corneal shape. He held up a series of convex mirrors of different curvatures next to the eye until he found one which gave an image of same size as the image from the cornea.

In 1820's, **Cuigent** developed a **keratoscope** through which he observed the reflected image of illuminated target held in front of patients cornea.

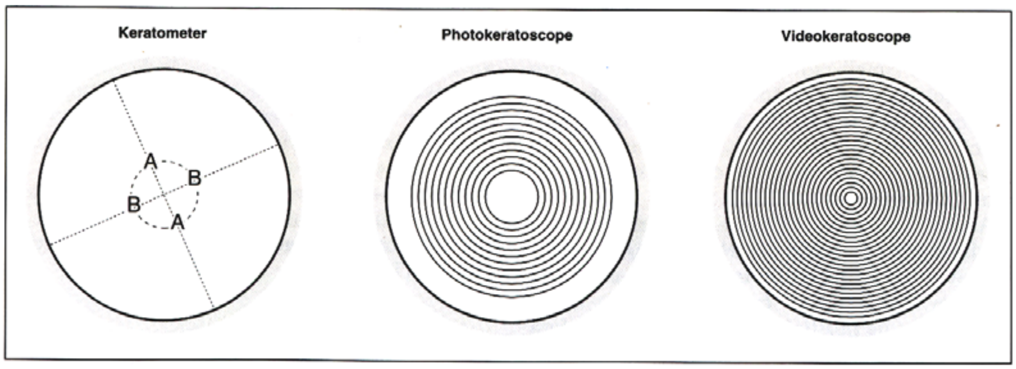
In 1882 **Placido,** placed an observation hole in the centre of the target. His target was a disc bearing alternate black and white concentric rings and this pattern still forms the basis of many topographic systems today.

Quantification of corneal curvature became possible in 1854 with the development of Keratometer by **Von helmholtz**. The distance between 2 pairs of reflected points gave the spherocylindrical curvature of the central 3mm of cornea in 2 meridians.

In order to increase the area of cornea analysed, **Javal** (1889) attached a placido type disc to his keratometer which gave him the benefit of magnified keratoscopy.

In 1896 **Gullstrand** applied photography to keratoscopy (photokeratoscopy).

With the development of microsurgical techniques for cataract extraction, corneal grafting and incisional refractive surgery, interest turned to the optical power provided by the cornea. Measurement of corneal curvature can be converted to dioptric power using the standard keratometric index.



As visual result of these procedures have improved, fine tuning of refractive outcome has become increasingly important. The more recent explosion of refractive surgery has opened up new avenues for the development of topographic systems. This is particularly true for PRK in which a precise depth of tissue is removed from anterior corneal surface. As a result new topographic systems based on principle of projection rather than that of reflection are being developed.

Methods of Measurement

Falls into 2 main categories :

- based on principle of **reflection**
- based on principle of **projection**.

1. Reflection based

Majority of topography systems are based on this principle

Examples include Keratometer and Video keratoscope.

They measure slope of corneal surface and can use this information to calculate radius of curvature and power. It does not measure elevation.

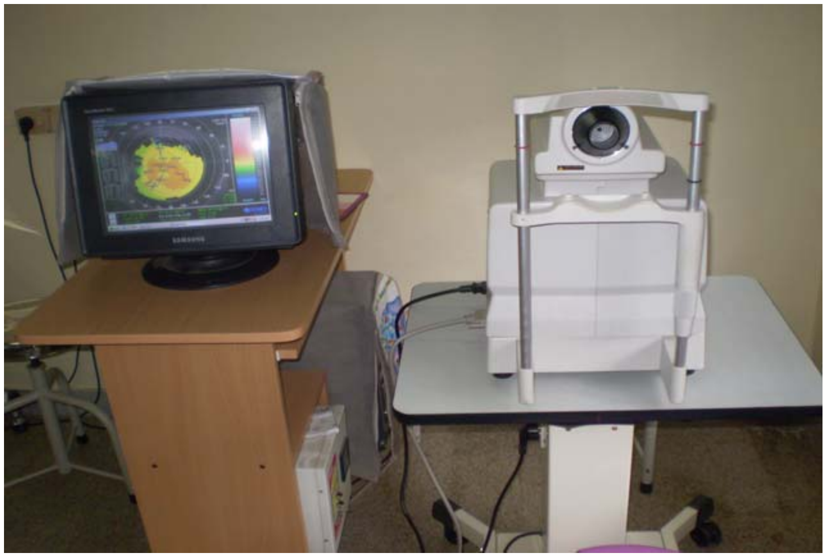
2. Projection based

Newly developed systems make use of this principle.

Examples include Slit photography, Rasterstereography, Moires interference, Laster interferometery.

They measure the true corneal shape in terms of elevation from which slope, curvature and power can be calculated.

Computer assisted video keratoscopy



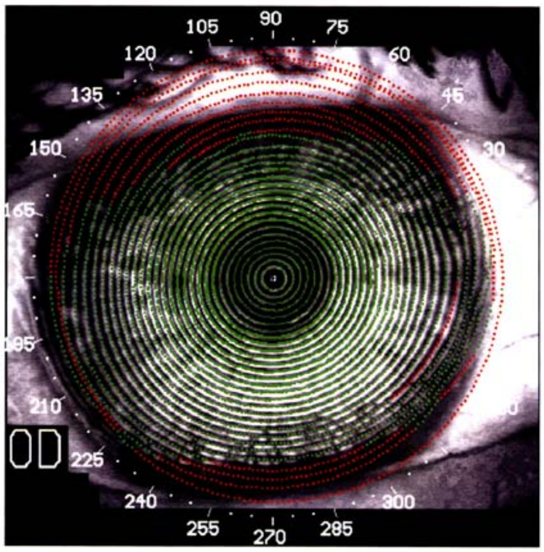
- Steps involved

1. Patient positioned correctly
2. Patient fixates target
3. Placido disc Illuminated
4. Mires reflected from corneal surface
5. Clinician focuses and aligns the mires
6. Clinician triggers image acquisition
7. CCD video camera records image
8. Framegrabber captures image
9. Digitisation of image
10. Position of mires identified
11. Reference point established

12. Data points located

13. Algorithm applied

14. Display of results



Measurements

Raw Image

Study of raw image captured by the camera in the topography can demonstrate focal irregularities which corresponds to surface pathology or tear film abnormalities.

Height

Height is available by the principle of projection. A 3D map gives a good concept of overall shape of cornea.

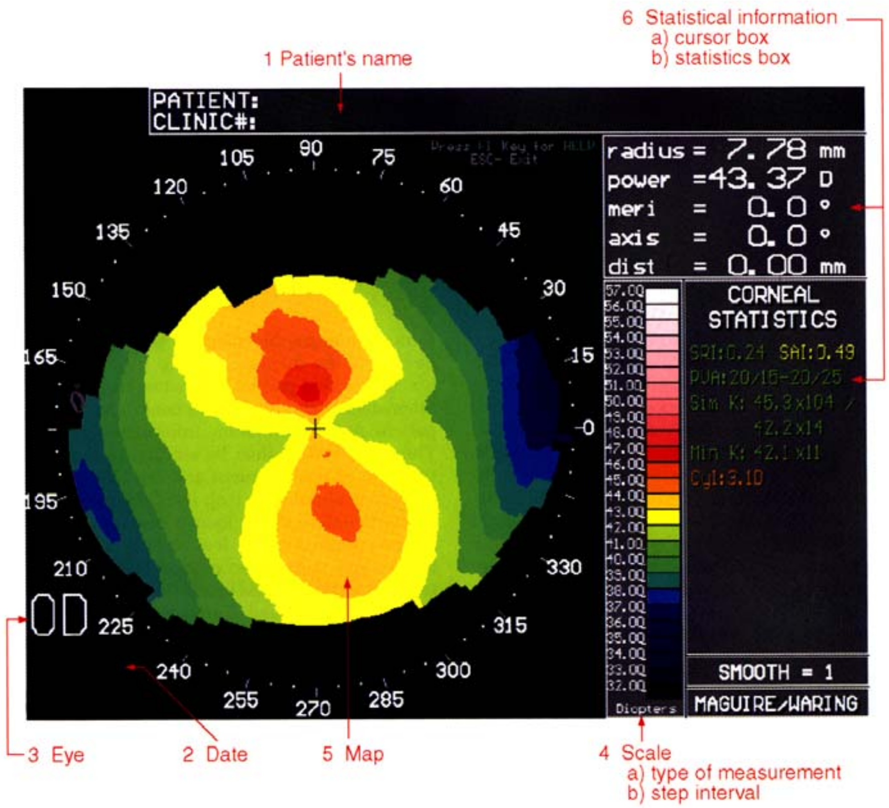
Slope and Curvature

They represent rate of change of height and are a much sensitive measure of variation in contour across the corneal surface.

Power

Refractive power can be calculated.

Two Dimensional Maps



1. Colours

Warm: (orange,red,white)- represents steeper surfaces with greater dioptric power.

Cool(blue, black,azure)- represents flatter surface with lesser dioptric power.

2. Scales : Label on the scale gives the type of measurement which is being displayed.

Height is expressed in mm/μm , slope(no units) ,curvature (mm)power (dioptre)

- **Absolute scale** is one in which there is a fixed colour coding system; the same colours always represent the same curvatures or powers.

The allocation of colours is related to distribution of corneal powers in normal population.

- **Normalised / reactive scale** uses a set number of colours which are automatically adjusted to fill the range of dioptric values for that single map.

- **Adjustable scale** : This enables the operator to select the step interval and dioptric range of the contours.

Statistical Indices

These are numbers which summarise a particular feature of the cornea.

- **Simulated Keratometry Reading (Sim K)**

Provide information equivalent to that measured by keratometer. Calculated by determining the average power along each meridian in the central (within 3mm zone) or paracentral (rings 7-9) area. The major axis is that with the greatest power and the minor axis is 90^o to it.

- **Min K**

It is the meridian with the lowest mean power. Cylinder is the difference between major and minor axes.

- **Sphero Equivalent Power**

It is the effective refractive power of the cornea within the 3mm pupillary zone, taking into account the Stiles - crawford effect. It is more reliable than keratometry for calculation of power of IOL.

- **Asphericity**

It is a measure of flattening or steepening of midperiphery. It is important for optical aberrations following refractive surgery.

- **Surface Asymmetry Index**

It is a measure of difference in corneal powers between 2 points on the same ring 180^o apart. It is calculated from the entire corneal surface. It is a useful quantitative indicator of progression of corneal diseases such as keratoconus or peripheral corneal gutters.

- **Inferior-Superior Value - (I-SV) :**

It is calculated from the refractive power difference between five inferior and five superior points 3mm from the centre at 30^o intervals.

- **Keratoconus Prediction Index:** derived from

    1. Sim K_1
    2. Sim K_2
    3. SAI
    4. Differential sector index (DSI)
    5. Opposite sector index (OSI)
    6. Centre surround index (CSI)
    7. Irregular astigmatism index (IAI)
    8. Analysed area (AA)

- **Surface regularity Index**

It is a measure of local regularity of the corneal surface within the central 4.5mm diameter. This index correlates well with visual function.

- **Potential visual acuity (or) predicted corneal acuity** is the estimated range of visual acuity which could be expected if the cornea was the only factor limiting vision.

TOPOGRAPHIC MODELING SYSTEM:(TMS)

- It is based on old principle of placido disc
- It incorporates many luminous concentric rings

On each ring 256 points are identified and sampled to provide data from which the radius of curvature is computed.

- These rings give corneal reflections at 180 μm internals
- It provides 7,000 data points in toto
- It gives an accuracy of 0.10 D
- 2 cones are used
- 25 ring cone is for standard use. It covers 8.5mm of cornea
- 31 ring cone projects rings farther peripherally and covers 11mm diameter of cornea. This is recommended for contact lens fitting.

4 types of map

1. Standard
2. Refractive
3. Instantaneous
4. Height

- **Standard**

Displays refractive powers in parallel.

A spherical cornea without astigmatism is displayed in one colour in this map.

- **Refractive**

Indicates refractive power by regarding cornea as lens.

Good for optical analysis.

- **Instantaneous**

Shows local slope of cornea

Good indicator of keratoconus and used to identify the borderline between the portion cut out by PRK or laser and its surrounding area.

Bogan and co workers classified normal human corneas into 4 types

A. Round and oval pattern - very low astigmatism (Figure 1)

B. Symmetrical bow tie - symmetrical astigmatism (Figure 3)

C. Asymmetrical bow tie (Figure 4)

D. Irregular pattern (Figure 2)

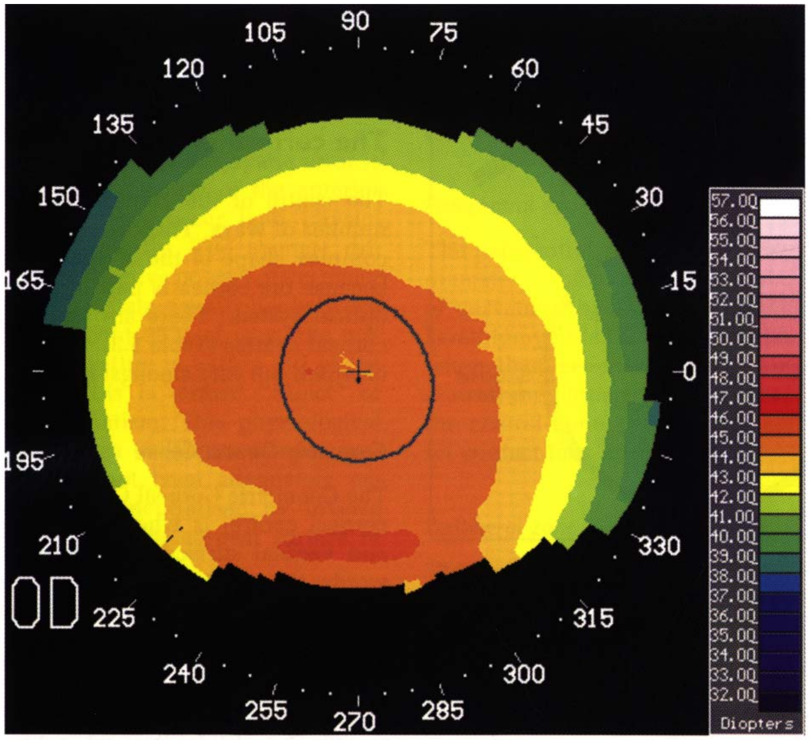


Figure 1

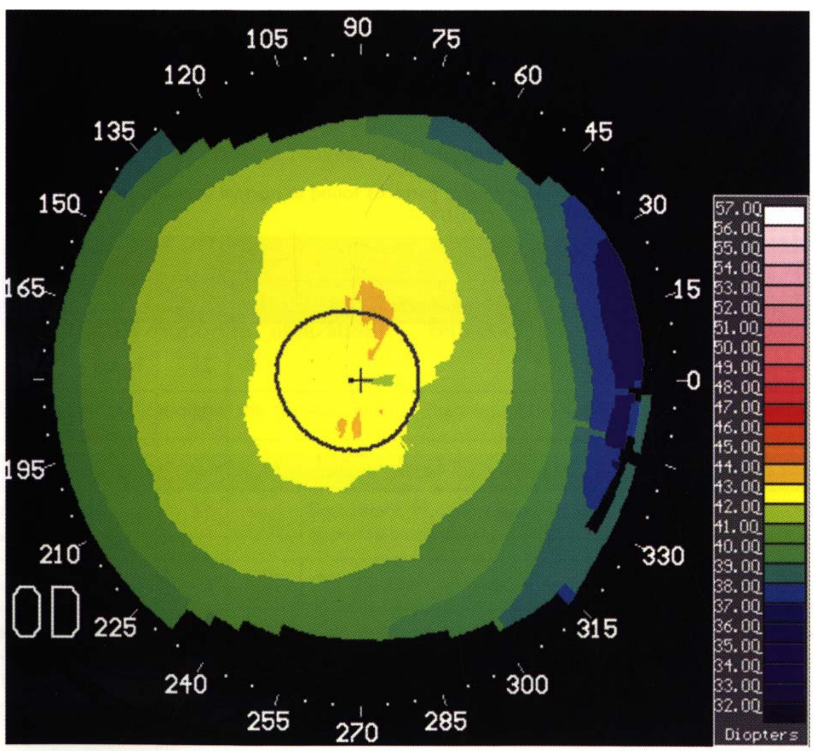


Figure 2

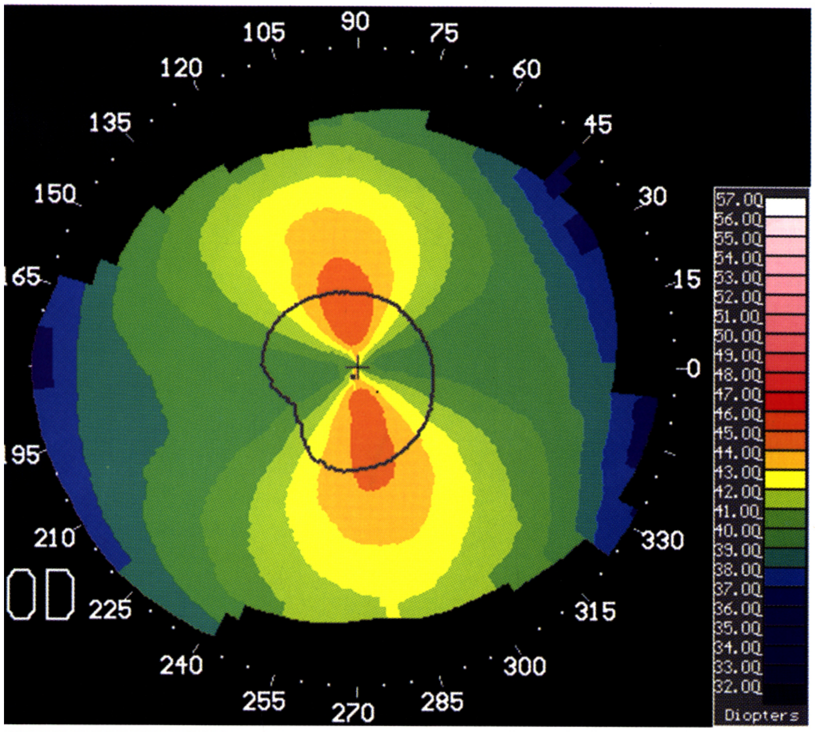


Figure 3

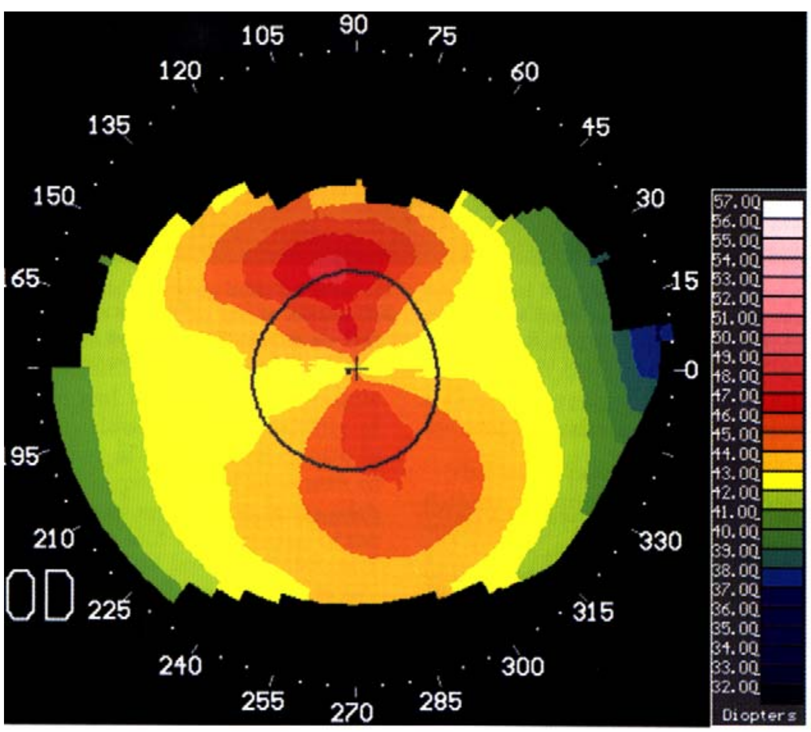


Figure 4

Astigmatism and topography

Topography displays difference in curvature of 2 principal corneal meridians as a bow tie pattern. In normal conditions, the bow tie is oriented along the steeper meridian, the colour of the bowtie is itself warmer than the surrounding corneal surface.

During measurement, the radius of curvature are referred to the videokeratoscopic axis that intersects the cornea at the normal vertex. This explains the bow tie pattern in astigmatic cornea, the bow tie demostrates that the 2 principal meridians have different powers. Intermediate meridians have intermediate power, this is greater closer the intermediate meridian is to the steeper principal meridian.

The normal vertex is in the centre of the bow tie. It behaves like the nodal point of a lens where there is no deviation of the light rays.

If the cornea were a regular spherocylindrical surface, astigmatism would be represented by a propeller profile. There are 2 reasons for bow tie aspect in which peripheral parts of the propeller tend to be reduced in dimensions.

- First - the flatter periphery of the cornea tends to reduce the dioptric power over those meridians next to the steeper principal meridians.

- Second - astigmatism is confined to the central cornea and does not reach the periphery.

Size of the bowtie is not related to the amount of astigmatism.It indicates only the extent of astigmatic changes over the corneal surface.

It is the colour difference between the 2 principal meridians that reflects the amount of astigmatism, the greater the colour difference, greater the astigmatism.

- Symmetrical bowtie indicates a symmetrical cylinder.
- In asymmetrical bowtie the dioptric power is not symmetrically distributed along the two semimeridians.

Symmetry does not correspond to intersection of line of sight . Thus astigmatism may be topographically asymmetric but relatively symmetric if 2 parts of the bow tie overlying the pupil are symmetric.

Irregular astigmatism - Topographic pattern

- ❖ Semi meridional - the dioptric power of a meridian is not equally distributed along the 2 semimeridians (eg. kerotoconus)
- ❖ Oblique - 2 principal meridians are not perpendicular to each other. (eg after keratoplasty)
- ❖ Oblique semimeridional - 2 steeper or flatter semimeridians do not belong to the same meridian (eg. early Pellucid Marginal Degeneration)
- ❖ Diffuse - all other patterns (eg. corneal dystrophy)

Age Associated Clinical Alterations in the Cornea

All the histological layers of the cornea undergo changes.

- **Corneal Tear Film**

An age associated increase in incidence of bacterial infections of the cornea has been suggested. There is an increase in the mucin component of tears from elderly individuals when compared to young subjects. This leads to adherence of several bacterial organisms and may explain the susceptibility to corneal infection in the elderly.

- **Epithelium**

Epithelium undergoes spontaneous alteration in the corneal limbal surface ascribed to senile changes called as fuchs dimples. These are shallow elliptical excavations measuring 1.5-2mm in diameter, with clearly defined edges, sloping borders and a faint opacity in the floor. They are due to focal thinning or a loss of surface epithelium, Bowman's membrane and anterior stroma. They are believed to be caused by local atherosclerosis or by dessications.

Changes in the epithelial cell permeability occurs with aging. There is a decrease in epithelial barrier function in elderly when compared to younger individuals. Deposition of iron in the cytoplasm of corneal epithelial cells called as Hudson-stahli line occurs in 75% of patients above 50 years. Iron is derived from tears and is deposited in the inferior cornea in a horizontal line about 0.5mm wide. The location of the line usually coincides with the line of closure of the eyelids, a region of focal tear pooling during eye closure. Clinically, the line appears slight brown and is best seen under cobalt blue illumination. Histologically, the iron is concentrated in the deeper cellular areas of epithelium and is best seen with iron stains such as prussian blue or perl's stain. However, it is of no consequence to corneal health or vision.

- **Corneal sensitivity**

The sensory nerves to the cornea are derived from ophthalmic branch of trigeminal nerve. They enter the cornea at the limbus, travel centripetally near the Bowman's membrane and finally arborize with in the basal epithelial cells. Beginning at the age of 40, the threshold for sensitivity to corneal touch increases and continues to do so with advancing maturity. This can be attributed to change in corneal mechanoreceptors.

- **Bowman's layer**

Collagen fibres from the stromal layers insert obliquely into Bowman's layer. With age and sustained hypotony, a relaxation of tension via these structures occurs probably as a result of alterations in collagen with in the stroma, leading to a presentation-bilaterally of polygonal opacities interrupted and bordered by clear translucent lines, which intersect around opacities in a mosaic pattern called Anterior crocodile shagreen (mosaic shagreen of vogt). This finding can be seen in many patients older than 50 yrs and is considered to represent an aging phenomenon.

Corneal arcus appears to be a prognostic factor for the development of CHD in men below 50 yrs and of elevated cholesterol and LDL in patients above 50 years. Arcus senilis results form the deposition of cholesterol, cholesterol esters and fat in the extra cellular spaces of peripheral corneal stroma; this phenomenon appears first in the more posterior layers and spares the peripheral 0.25mm. In advanced layers, it is also seen in the Bowman's layer, in descemets membrane and between the scleral lamella. The opacity first appears inferiorly in the cornea, then progresses circumferentially, separated from the corneal limbus by a clear zone, the lucid interval. The leakage of fatty products from the age affected perilimbal vasculature could be a cause.

Marginal atrophy is a corneal thinning in the periphery of the cornea that occurs in association with arcus senilis. A fragmentation of peripheral collagen results in a noninflammatory depression at the corneal limbus, beginning superiorly that can even progress circumferentially. The epithelium overlying the furrow is intact.

Posterior crocodile shagreen has a mosaic like clinical appearance similar to Anterior type. Cloudy regions appear in the central cornea as a result of alteration in collagen lamination in the posterior stromal layers.

- **Corneal Endothelium and descemets membrane**

Early in fetal life, the endothelial cells of cornea assist in the elaboration of type IV collagen and other glycoprotein like material.

Descemets membrane generation of membrane material then continues throughout life with doubling in thickness every 40 yrs, it measures 2µm at age 10 years and 10µm at 80 years. The anterior 1/3 is produced in utero and is 3µm thick with a 100nm banding pattern.

The posterior portion produced exutero in nonbanded and homogenously granular. The membrane remains relatively uniform in thickness until age of 30 yrs after which nodular excrescences appear in the peripheral areas. These consitute "Hasal Henle bodies" – universally found in elderly. They represent focal over production of basement membrane material. It is postulated that focal alteration in endothelial cell homeostasis results in modified production or depsition of membrane material in non planar fashion.

Corneal endothelium is normally constructed of regular hexagonal array of interdigitating cells arranged in a monolayer about 5µm thick .Cell density at birth is 3,000 cells / sq mm and declines with age. At 80, cell counts range from 900-4000 cells /sq.mm. Miotic division of endothelial cells is not known to occur after birth. Death of endothelial cells is followed by hypertrophy and migration of neighbouring cells with a concomitant doubling of average individual cellular area between 20-80 yrs. By middle age, this results in a mosaic of cells composed of variably interdigitating cell bodies with widely different size and shapes.

With age, the percentage of normally shaped and sized cells declines further. This variation is more peripherally than centrally. Because the primary deturgescent pump mechanism acting to keep cornea dehydrated and optically clear are located in the endothelium, alteration in the cell density or cellular structure of these cells can precipitate decremental changes in clarity and vision.

AIM

To investigate the age related differences in corneal topography of a normal population.

It is a well known fact that against the rule astigmatism has a considerably higher incidence in older age. Many kinds of keratorefractive surgeries have been developed and are now popular. When performing such kinds of surgery, it is necessary to actually evaluate each patients corneal shape. Further more, a good understanding of the changes in corneal shape due to aging is also considered to be essential. The present study was designed to evaluate the aging changes in corneal shape using computed videokeratography.

MATERIALS AND METHODS

This documentation has been arrived at the end of study of 152 patients divided prospectively into three groups.

The entire evaluation was carried out at RIO- GOH, Egmore, Chennai. The study began in June 2005 to May 2006 covering a period of 12 months.

Similarity of the cases studied was maintained as far as possible. The strategy included selection of age factor and uncomplicated cases.

Inclusion Criteria

- Normal cornea
- No history of any ocular surgery
- No abnormalities on slitlamp examination
- Regular Keratometric mires
- No History of Contact lens wear.
- No History of any other ocular ailments other than refractive errors.

Before topography was done,

- Visual acuity
- Refraction

- Slitlamp examination
- Keratometry was done

The corneas were divided into 3 groups

a 21-40 years

b 41-60 years

c 61-80 years

Number of eyes in

- Group a - 86
- Group b - 77
- Group c - 80

making a total of 243 eyes of 152 patients.

The patients were selected based on inclusion and exclusion criteria laid down. The patients were subjected to refraction, slitlamp examination and keratometry. A thorough ocular history was taken. All the selected patients were then examined by videokeratography with topographic modeling system (TMS-4). All the examinations were performed by a single person over a period from June 2005 to May 2006. Videokeratograph was taken was taken thrice times for each eye. The keratographs were processed by the computer into absolute scale map of TMS and the maps were reviewed.

The highest quality keratograph was selected and stored. Videokeratographic images were displayed with the absolute scale map (1.5D/contour interval). Colour coded topographic maps with the highest quality were then selected and analysed. All the mires with in the central 1.5mm radius (central 10 mires) needed to be complete to be included in the study. The astigmatism pattern was established by analysing the axis.

70^o-110^o	with the rule
160^o-20^o	against the rule
in between	oblique

Statistical Analysis

All topographic indices were expressed as means and standard deviation of means. Statistically significant differences were assessed with chi square test.

OBSERVATION AND ANALYSIS

The results of the 3 groups were analysed.

Group a : 21-40 years

86 eyes of 50 patients were examined in this group 14 eyes had to be excluded because of history of trauma to the eye or irregular mires on examination etc.

- The topographic map of patients in this group showed the vertical bow-tie shaped steep area in central cornea in which the refractive power was between 43 and 44.5D (yellow) which thus indicates **"with the rule"** astigmatism. The peripheral cornea of these patients was relatively flat and refractive power was between 41.5 and 40.0D (green).
- The refractive power of the horizontal meridian (0-180^o) were lower than those in vertical meridians (90-270^o).

Table 1a

Type of astigmatism	**With the rule**	**Oblique**	**Against the rule**
No. of patients	76	4	6
Percentage (%)	88.4%	4.7%	7.0%

On analysis of the data, of the 21-40 age group, it was found that 88.4% of eyes had with the rule astigmatism, 7% of eyes had against the rule astigmatism and 4.7% of eyes had oblique astigmatism.

Table 1b

Category	Frequency	Percentage	P value
With the rule	76	88.4%	< 0.001 (significant)
Against the rule	6	7.0%	
Oblique	4	4.7%	

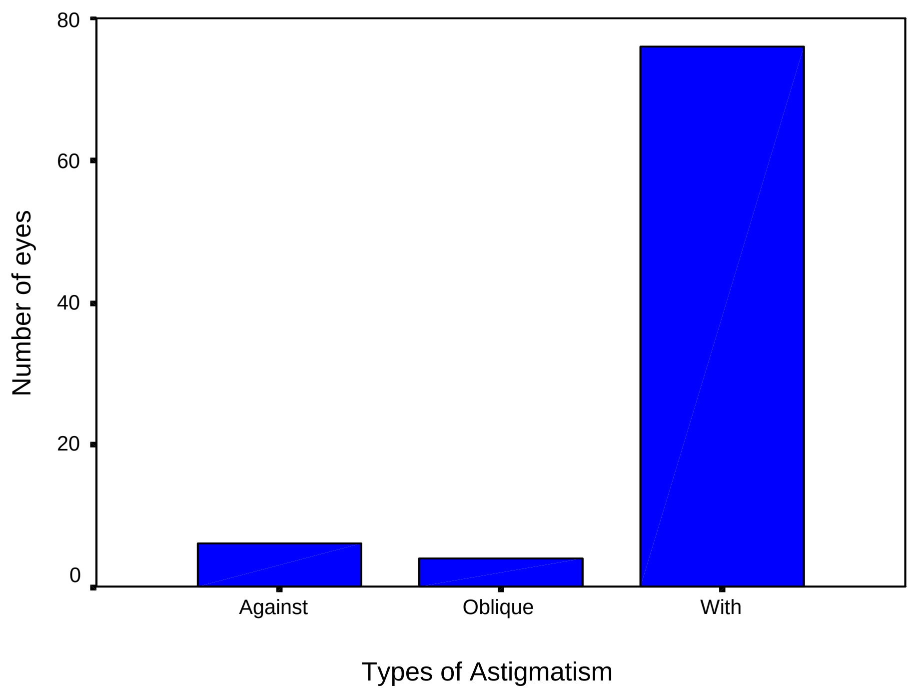
Reference

P value ≤ 0.01 - significant at 1% level

P value (0.011 to 0.05) - significant at 5% level

P value (>0.05) - not significant at 5% level

By the chi square test, p value was found to be less than 0.001 and thereby it is statistically significant.



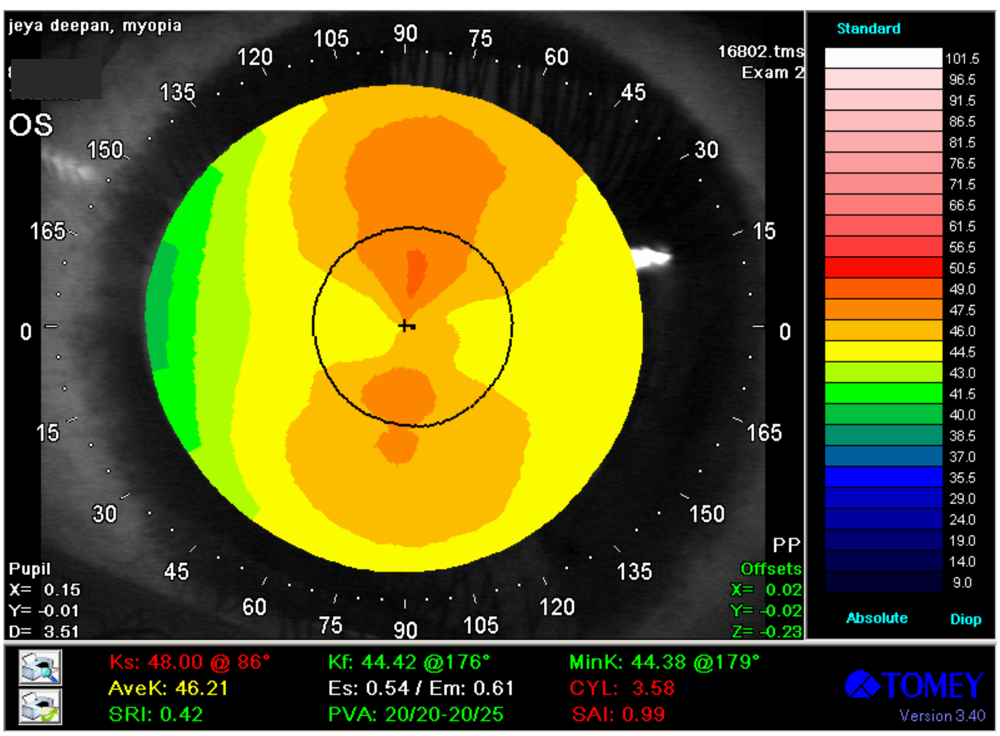
Group A

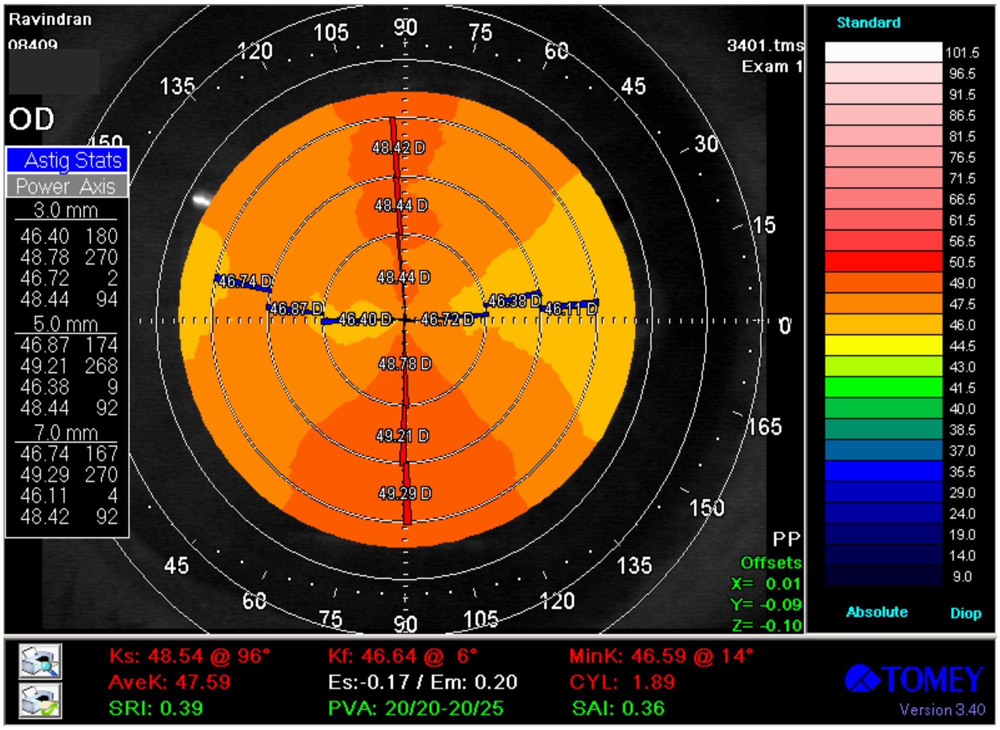
This coincides with the study conducted by Hayashi et al in 1995[14,15].

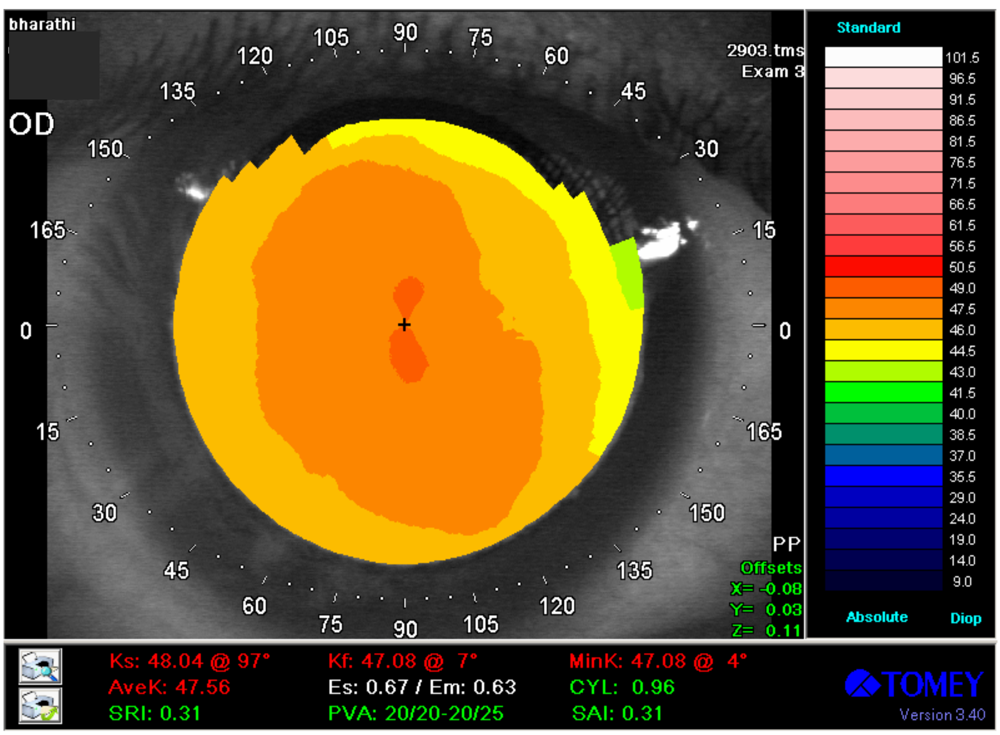
Table 1

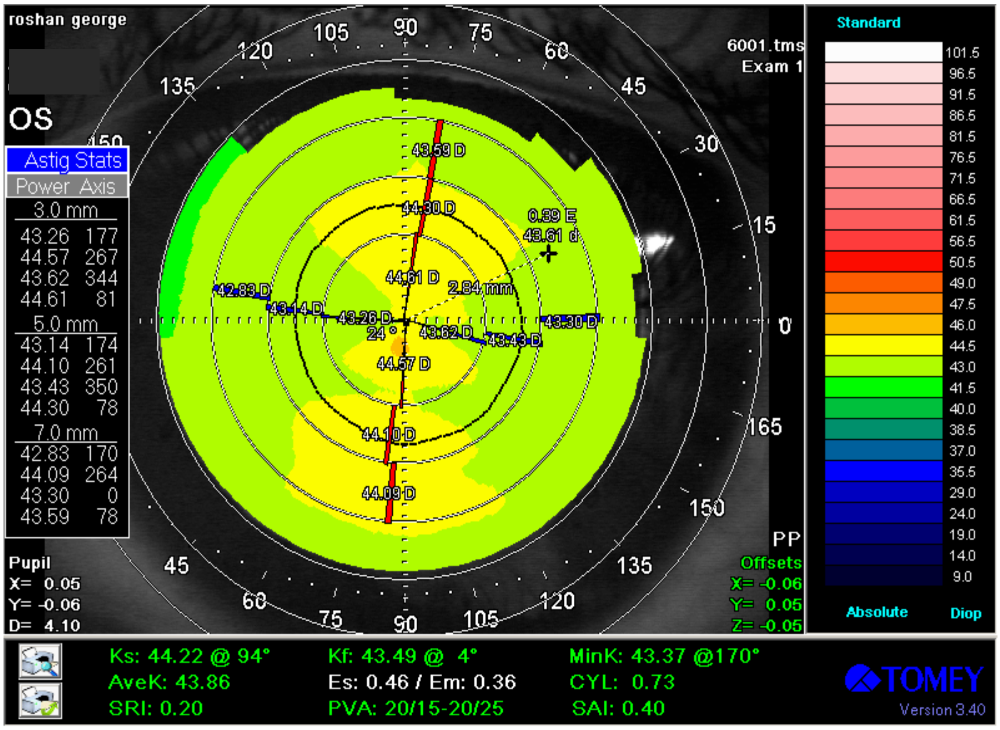
Right Eye		**Left Eye**	
Mean K_s Vertical Axis	**Mean K_f Horizontal Axis**	**Mean K_s Vertical Axis**	**Mean K_f Horizontal Axis**
44.87	42.74	44.54	42.18

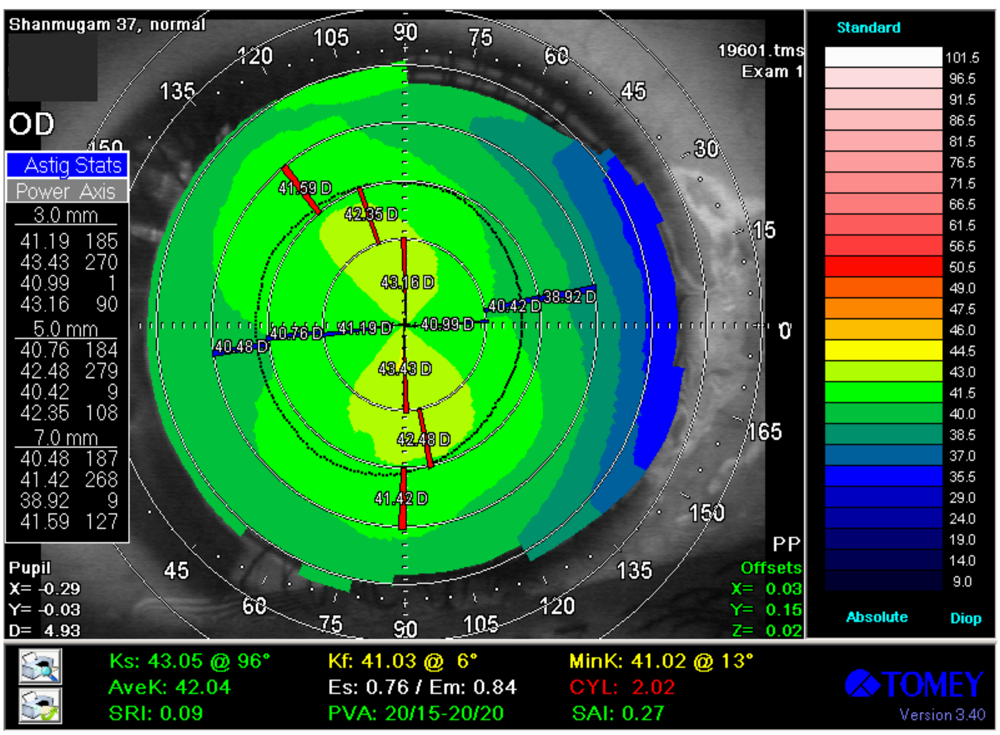
On analysis of table 1 of patients in **group a** it is found that the steeper meridian is predominantly in the vertical axis.




Ravindran
08409
OD
3401.tms
Exam 1
Astig Stats
Power Axis
3.0 mm
46.40 180
48.78 270
46.72 2
48.44 94
5.0 mm
46.87 174
49.21 268
46.38 9
48.44 92
7.0 mm
46.74 167
49.29 270
46.11 4
48.42 92
48.42 D
48.44 D
48.44 D
46.74 D
46.87 D
46.40 D
46.72 D
46.38 D
46.11 D
48.78 D
49.21 D
49.29 D
PP
Offsets
X= 0.01
Y= -0.09
Z= -0.10
Standard
101.5 96.5 91.5 86.5 81.5 76.5 71.5 66.5 61.5 56.5 50.5 49.0 47.5 46.0 44.5 43.0 41.5 40.0 38.5 37.0 35.5 29.0 24.0 19.0 14.0 9.0
Absolute
Diop
Ks: 48.54 @ 96°
Kf: 46.64 @ 6°
MinK: 46.59 @ 14°
AveK: 47.59
Es:-0.17 / Em: 0.20
CYL: 1.89
SRI: 0.39
PVA: 20/20-20/25
SAI: 0.36
TOMEY
Version 3.40


bharathi
OD
2903.tms
Exam 3
PP
Offsets
X= -0.08
Y= 0.03
Z= 0.11
Standard
101.5 96.5 91.5 86.5 81.5 76.5 71.5 66.5 61.5 56.5 50.5 49.0 47.5 46.0 44.5 43.0 41.5 40.0 38.5 37.0 35.5 29.0 24.0 19.0 14.0 9.0
Absolute
Diop
Ks: 48.04 @ 97°
Kf: 47.08 @ 7°
MinK: 47.08 @ 4°
AveK: 47.56
Es: 0.67 / Em: 0.63
CYL: 0.96
SRI: 0.31
PVA: 20/20-20/25
SAI: 0.31
TOMEY
Version 3.40


roshan george
OS
6001.tms
Exam 1
Standard
Astig Stats
Power Axis
3.0 mm
43.26 177
44.57 267
43.62 344
44.61 81
5.0 mm
43.14 174
44.10 261
43.43 350
44.30 78
7.0 mm
42.83 170
44.09 264
43.30 0
43.59 78
Pupil
X= 0.05
Y= -0.06
D= 4.10
PP
Offsets
X= -0.06
Y= 0.05
Z= -0.05
Absolute
Diop
Ks: 44.22 @ 94°
AveK: 43.86
SRI: 0.20
Kf: 43.49 @ 4°
Es: 0.46 / Em: 0.36
PVA: 20/15-20/25
MinK: 43.37 @170°
CYL: 0.73
SAI: 0.40
TOMEY
Version 3.40


Shanmugam 37, normal
OD
19601.tms
Exam 1
Standard
Astig Stats
Power Axis
3.0 mm
41.19 185
43.43 270
40.99 1
43.16 90
5.0 mm
40.76 184
42.48 279
40.42 9
42.35 108
7.0 mm
40.48 187
41.42 268
38.92 9
41.59 127
Pupil
X= -0.29
Y= -0.03
D= 4.93
PP
Offsets
X= 0.03
Y= 0.15
Z= 0.02
Absolute
Diop
Ks: 43.05 @ 96°
AveK: 42.04
SRI: 0.09
Kf: 41.03 @ 6°
Es: 0.76 / Em: 0.84
PVA: 20/15-20/20
MinK: 41.02 @ 13°
CYL: 2.02
SAI: 0.27
TOMEY
Version 3.40

Group b: 41-60 years

77 eyes of 52 patients were examined in this group 13 eyes had to be excluded because of history of trauma to the eye or irregular mires on examination or history of ocular surgery.

- The topographic map of patients in this group reveals the cornea on the whole becomes steeper and attains a virtually round configuration.
- The refractive power of the horizontal meridian is almost nearing that of the vertical meridian.

Table 2a

Type of astigmatism	**With the rule**	**Oblique**	**Against the rule**
No. of patients	31	20	26
Percentage (%)	40.25%	25.97%	33.76%

On analysis of the data, of the 41-60 age group, it was found that 33.76% of eyes had against the rule astigmatism. 40.25% of eyes had with the rule astigmatism and 25.97% of eyes had oblique astigmatism.

Table 2b

Category	**Frequency**	**Percentage**	**P value**
With the rule	31	40.25%	0.909 (not significant)
Against the rule	26	33.76%	
Oblique	20	25.97%	

Reference

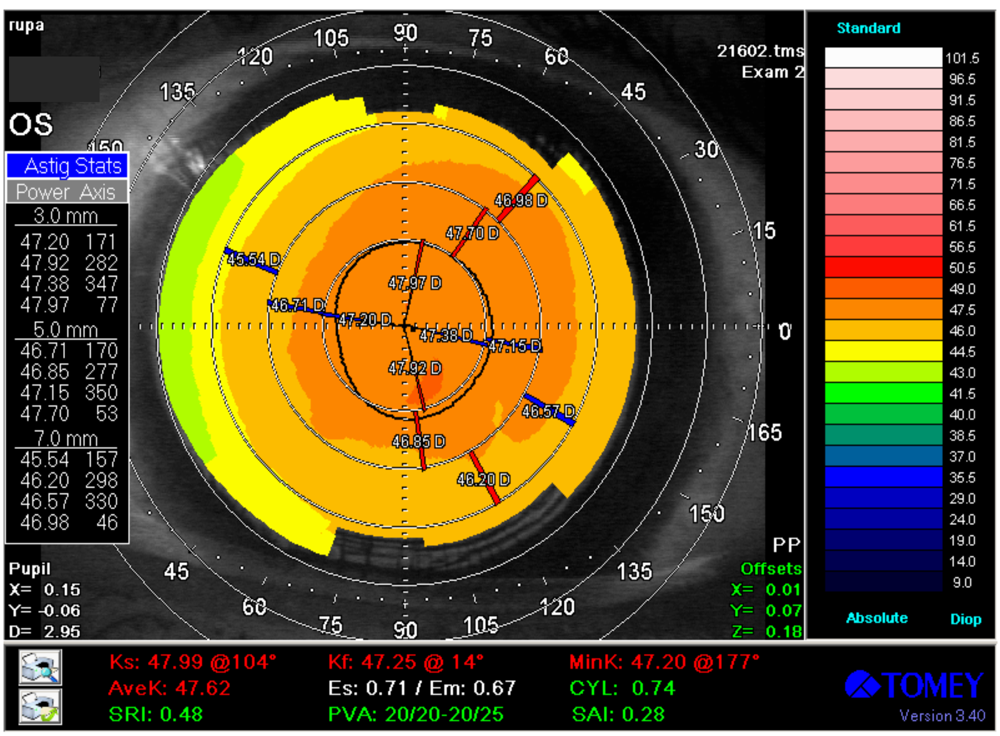
P value ≤ 0.01 - significant at 1% level

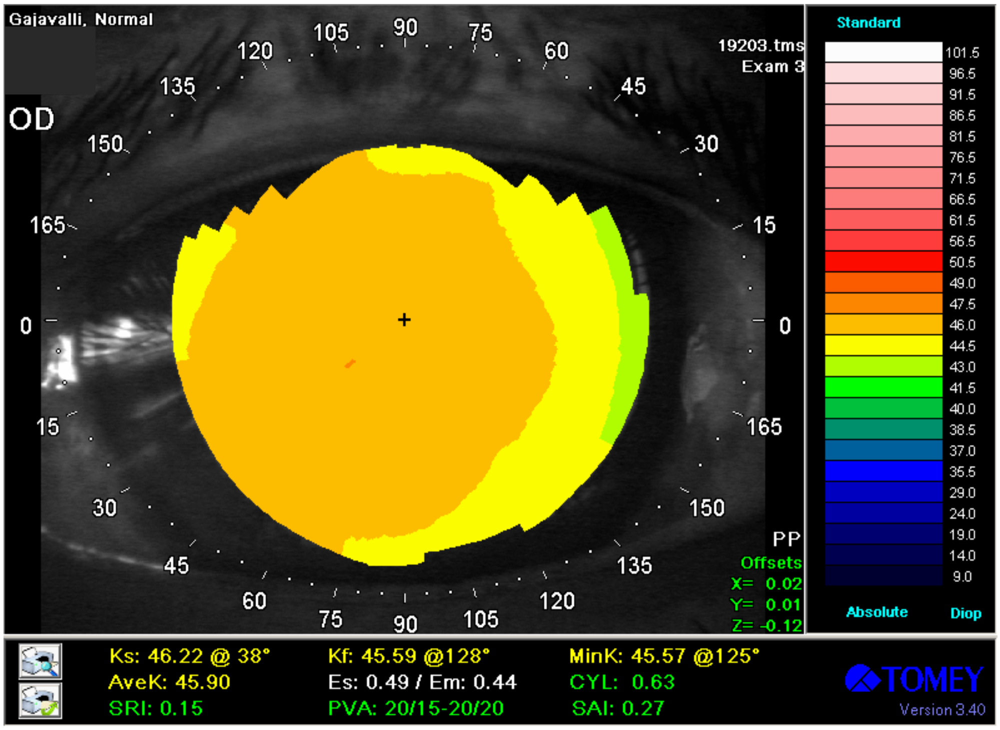
P value (0.011 to 0.05) - significant at 5% level

P value (>0.05) - not significant at 5% level

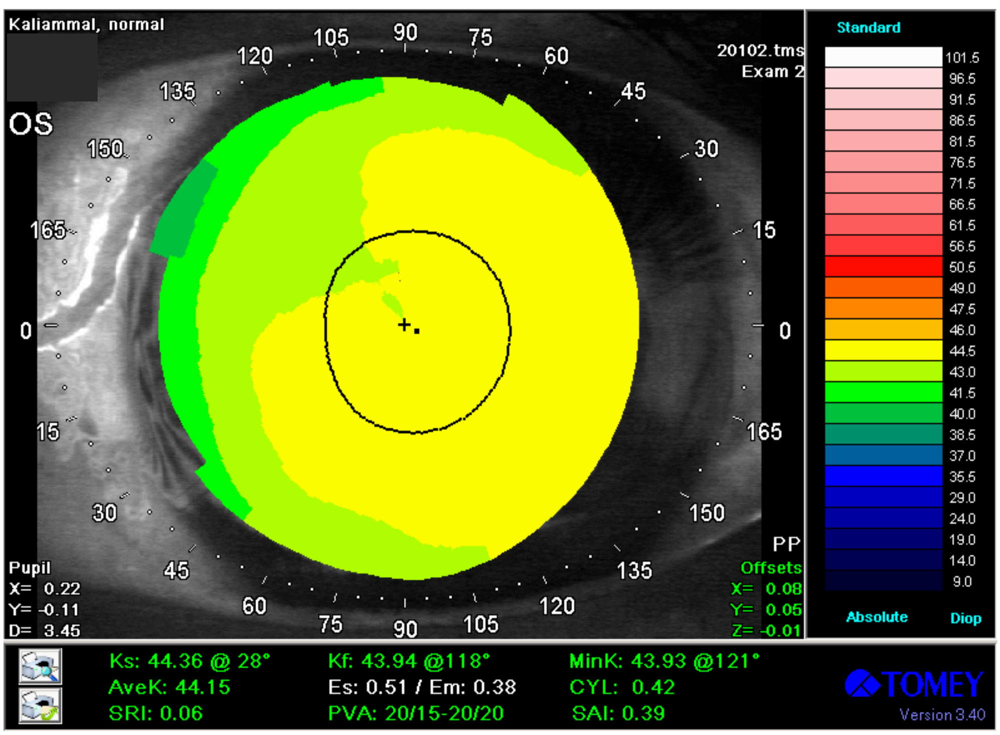
By the chi square test, p value was found to be 0.909 and thereby it is statistically not significant.

This coincides with the study conducted by Hayashi et al in 1995[14,15].





Gajavalli, Normal
[redacted]
OD
19203.tms
Exam 3
Standard
101.5
96.5
91.5
86.5
81.5
76.5
71.5
66.5
61.5
56.5
50.5
49.0
47.5
46.0
44.5
43.0
41.5
40.0
38.5
37.0
35.5
29.0
24.0
19.0
14.0
9.0
Absolute
Diop
PP
Offsets
X= 0.02
Y= 0.01
Z= -0.12
Ks: 46.22 @ 38°
AveK: 45.90
SRI: 0.15
Kf: 45.59 @128°
Es: 0.49 / Em: 0.44
PVA: 20/15-20/20
MinK: 45.57 @125°
CYL: 0.63
SAI: 0.27
TOMEY
Version 3.40



Kaliammal, normal
[redacted]
OS
20102.tms
Exam 2
Standard
101.5
96.5
91.5
86.5
81.5
76.5
71.5
66.5
61.5
56.5
50.5
49.0
47.5
46.0
44.5
43.0
41.5
40.0
38.5
37.0
35.5
29.0
24.0
19.0
14.0
9.0
Absolute
Diop
Pupil
X= 0.22
Y= -0.11
D= 3.45
PP
Offsets
X= 0.08
Y= 0.05
Z= -0.01
Ks: 44.36 @ 28°
AveK: 44.15
SRI: 0.06
Kf: 43.94 @118°
Es: 0.51 / Em: 0.38
PVA: 20/15-20/20
MinK: 43.93 @121°
CYL: 0.42
SAI: 0.39
TOMEY
Version 3.40

Table 2

Right Eye		Left Eye	
Mean K_s	**Mean K_f**	**Mean K_s**	**Mean K_f**
46.69	45.96	46.50	45.89

On analysis of Table 2 it is found that cornea as a whole becomes steeper.

Group c : 61-80 years

80 eyes of 50 patients were examined in this group 20 eyes had to be excluded because of corneal abnormalities like degeneration, bullous keratopathy or because of pseudophakia or irregular mires.

The topographic map of patients in this group showed the enlargement of central steep area to a horizontally oval shaped configuration, which suggests against the rule corneal astigmatism.

On examining the refractive powers, it is found that the refractive powers in horizontal meridian was greater than those in vertical meridian.

Table 3a

Type of astigmatism	**With the rule**	**Oblique**	**Against the rule**
No. of patients	6	10	64
Percentage (%)	7.5%	12.5%	80%

On analysis of the above, it is found that 80.0% of eyes had against the rule 12.5% had oblique and 7.5% had with the rule.

Table 3b

Category	Frequency	Percentage	P value
With the rule	6	7.5%	< 0.001 (significant)
Against the rule	64	80%	
Oblique	10	12.5%	

Reference

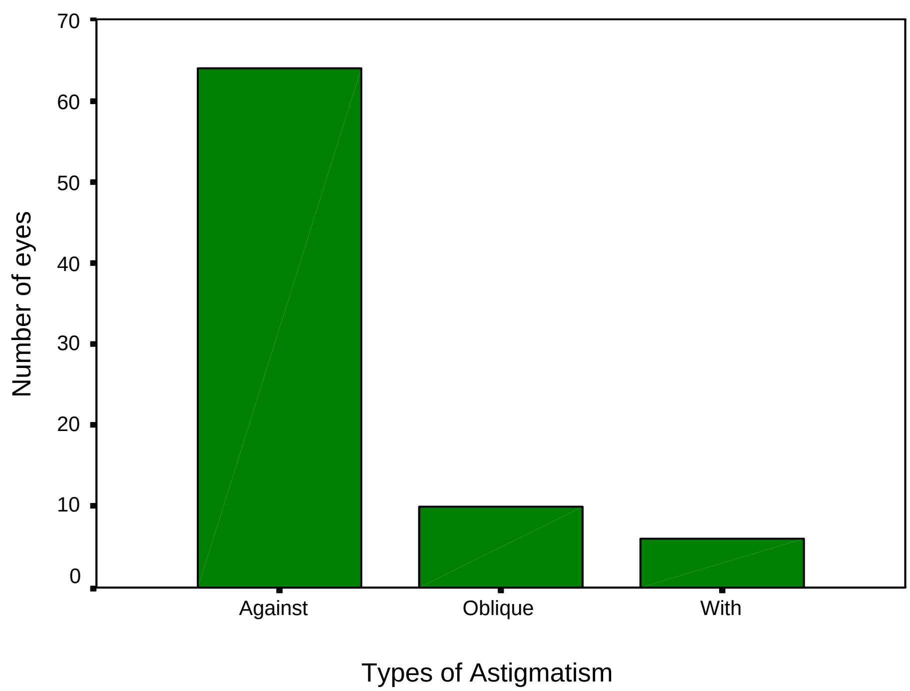
P value ≤ 0.01 - significant at 1% level

P value (0.011 to 0.05) - significant at 5% level

P value (>0.05) - not significant at 5% level

By the chi square test, p value was found to be less than 0.001 and thereby it is statistically significant.

This coincides with the study conducted by Hayashi et al in 1995[14,15].

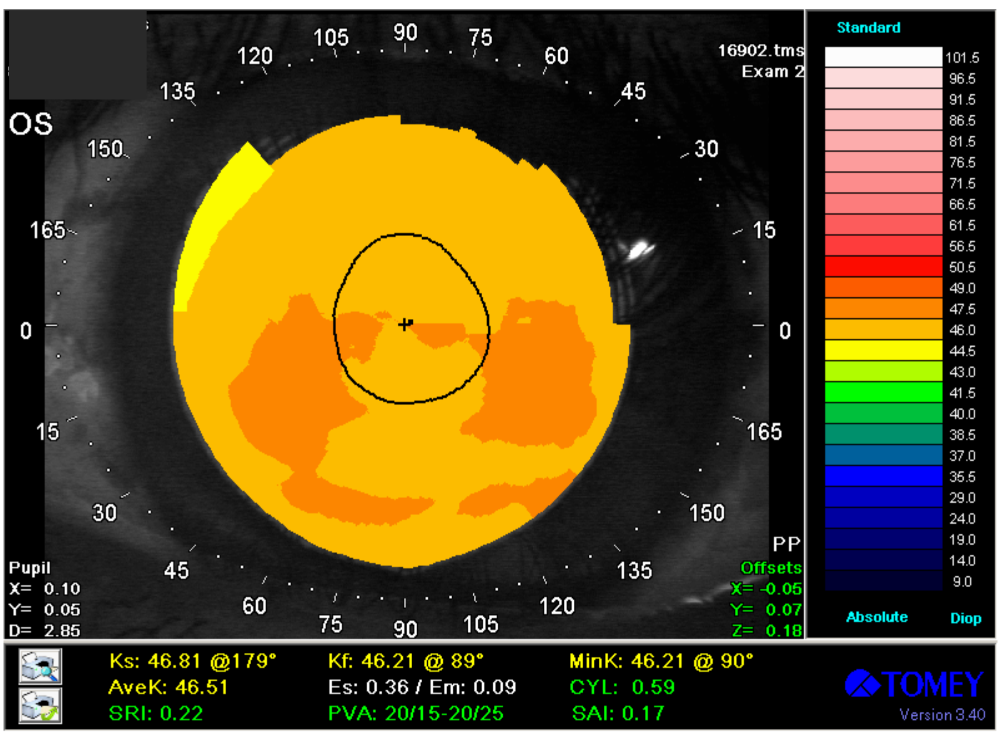


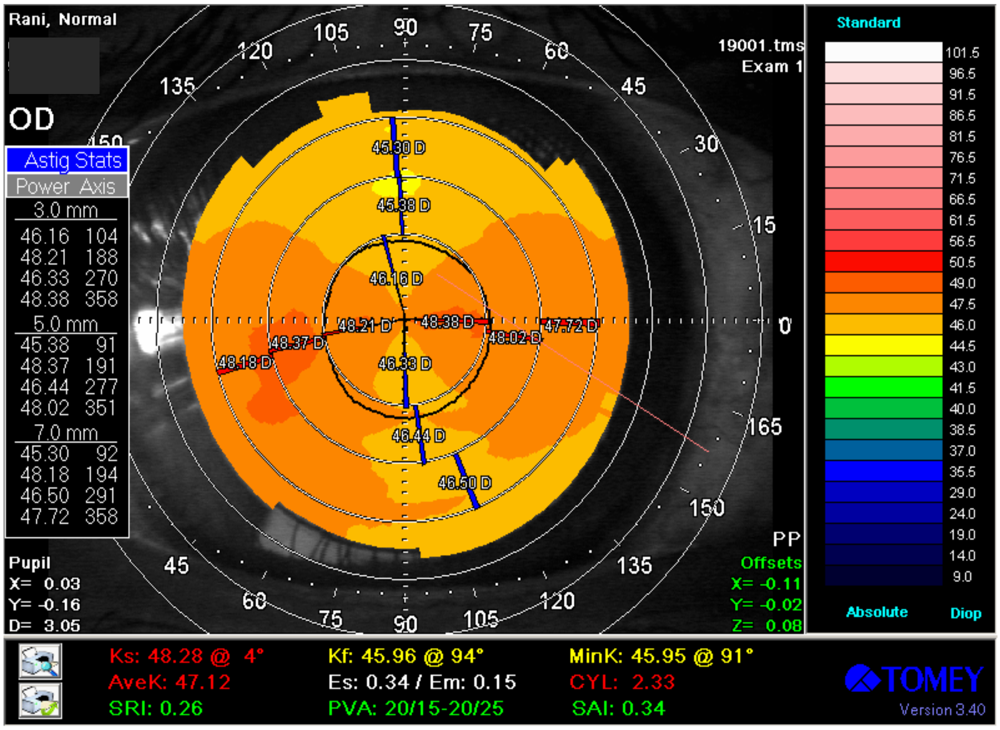
Group C

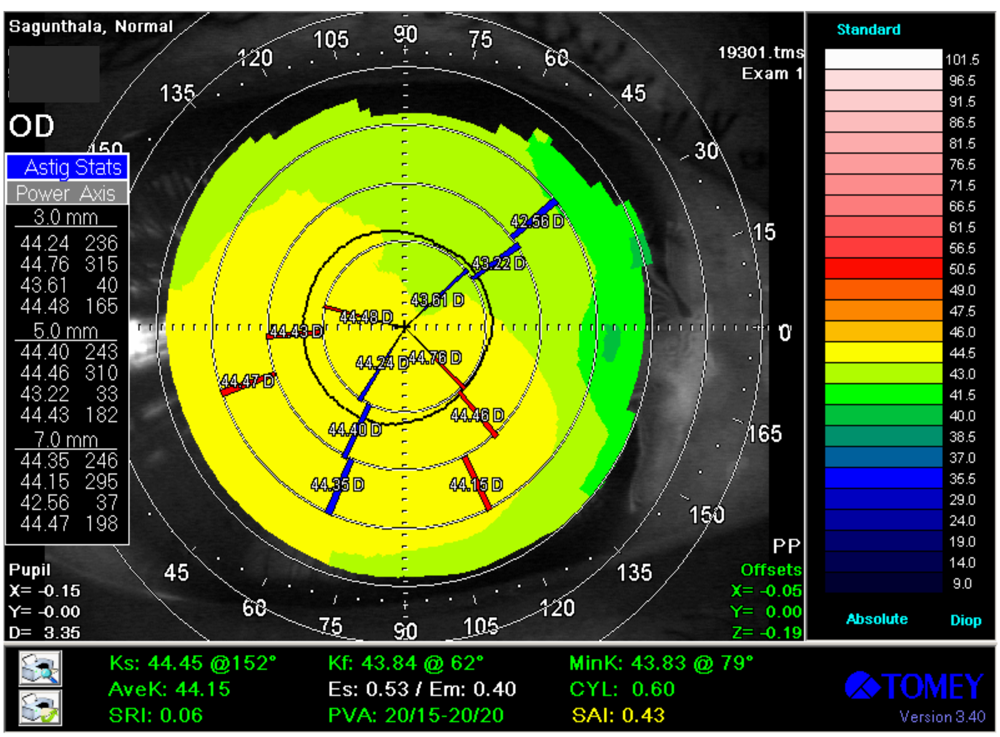
Table 3

Right Eye		Left Eye	
Mean K_s Horizontal Axis	**Mean K_f Vertical Axis**	**Mean K_s Horizontal Axis**	**Mean K_f Vertical Axis**
46.45	44.82	46.62	45.08

On analysis of Table 3 of patients in group C it is found that the horizontal meridian is steeper than the vertical meridian.




Rani, Normal
OD
Astig Stats
Power Axis
3.0 mm
46.16 104
48.21 188
46.33 270
48.38 358
5.0 mm
45.38 91
48.37 191
46.44 277
48.02 351
7.0 mm
45.30 92
48.18 194
46.50 291
47.72 358
Pupil
X= 0.03
Y= -0.16
D= 3.05
19001.tms
Exam 1
Standard
Offsets
X= -0.11
Y= -0.02
Z= 0.08
Absolute Diop
Ks: 48.28 @ 4°
AveK: 47.12
SRI: 0.26
Kf: 45.96 @ 94°
Es: 0.34 / Em: 0.15
PVA: 20/15-20/25
MinK: 45.95 @ 91°
CYL: 2.33
SAI: 0.34
TOMEY
Version 3.40

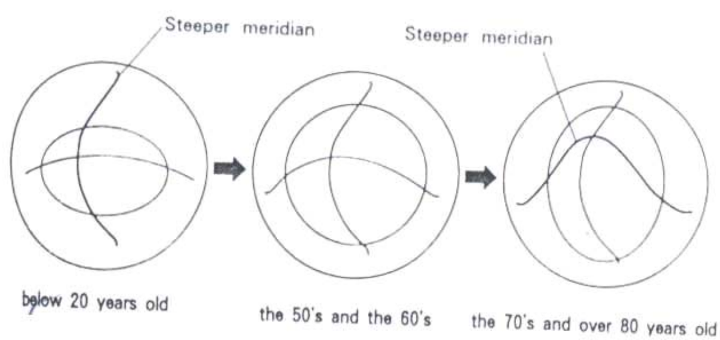

Sagunthala, Normal
OD
Astig Stats
Power Axis
3.0 mm
44.24 236
44.76 315
43.61 40
44.48 165
5.0 mm
44.40 243
44.46 310
43.22 33
44.43 182
7.0 mm
44.35 246
44.15 295
42.56 37
44.47 198
Pupil
X= -0.15
Y= -0.00
D= 3.35
19301.tms
Exam 1
Standard
Offsets
X= -0.05
Y= 0.00
Z= -0.19
Absolute Diop
Ks: 44.45 @152°
AveK: 44.15
SRI: 0.06
Kf: 43.84 @ 62°
Es: 0.53 / Em: 0.40
PVA: 20/15-20/20
MinK: 43.83 @ 79°
CYL: 0.60
SAI: 0.43
TOMEY
Version 3.40

DISCUSSION

Our study clearly shows that the normal cornea becomes steeper and shifts from with the rule astigmatism to against the rule astigmatism with age. The averaged map of the normal cornea at younger age showed vertical bow tie shaped steep area in central cornea which indicates **with the rule astigmatism**[14,15].

With aging, the cornea on the whole gradually becomes steeper and the central steep area extended horizontally. The subjects in and around 60's revealed a virtually round configuration[14,15] which implied that corneal astigmatism has been almost neutralised at this age.

For subjects greater than 60 the cornea shows a horizontally oval shaped steep area which is suggestive of **Against the rule** [14,15] astigmatism. The data analysis of changes in refractive powers clarified that against the rule astigmatic shift predominantly depends on steepening at horizontal meridians[16] (Ref. Table 1,2,3).



The causes of aging alteration in the cornea still cannot be clearly explained. The against the rule astigmatism shift in older age predominantly depended on **external influences**.

1. decline in upper eyelid pressure due to dermatochalasis

2. reduction action of medial rectus muscle

which leads to flattening of the horizontal meridian of cornea in older individuals.

Internal Factors

1. Progressive thickening of stromal collagen bundles

2. Decrease in interfibrillar spacing

3. Thickening of descements membrane

4. Degeneration of endothelial cells

All these alter the rigidity and elasticity of cornea leading to corneal steepening as well as astigmatic shift.

RESULTS

243 eyes of 152 patients were analysed in this study. 57 eyes had to be excluded because of either irregular mires, slitlamp abnormalities, corneal pathology, pterygium or because of pseudophakia.

The patients were categorized into 3 groups.

Group a	-	21-40 years
b	-	41-60 years
c	-	61-80 years

Topographic examination was done and the depending on the axis of the steeper meridian they were classified as having with the rule if steeper axis was between 70^o and 110^o, against the rule if the steeper axis was between 160^o-20^o and oblique astigmatism if steeper axis was in between.

In our study, **group a** (21-40 years) had with the rule astigmatism predominantly (88.4%) when compared to oblique (4.7%) and against (7.0%) the rule.

This coincides with the study conducted by Hayashi et al in 2001.

In **group b** patients of age 41-60 years 33.76% had against the rule astigmatism, 40.25% had with the rule astigmatism and 25.97% had oblique astigmatism. There is a gradual increase in against the rule astigmatism in this age group.

In **group c** patients of age 61-80 years, 80% was against the rule, 12.5% had oblique, 7.5% had with the rule astigmatism.

On analysis of topographic pattern of each group it is found that the vertical bow the pattern in the younger group (group a) gradually changes to almost round configuration in the group b (41-60 yrs) and as age further advances, it is found that the horizontal meridian steepens further and becomes a horizontal bow tie in group c (61-80 yrs).

On data analysis of change is refractive powers, it is found that this against the rule shift is predominantly due to steepening of horizontal meridians[16] (Table 1,2,3).

CONCLUSION

This study clearly demonstrates that the normal cornea becomes steeper and shifts from with the rule to against the rule astigmatism with age. The data anlaysis of change in refractive powers clarified that the against the rule shift occurs predominantly due to steepening of horizontal meridians.

Advances in keratorefractive surgeries have led to development of many new surgical techniques, which needs appropriate changes to be made to accommodate the aging changes in corneal shape. It is therefore essential to have a thorough understanding of aging changes in the corneal shape to obtain a stable and enduring refractive state after kerato refractive surgery.

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PROFORMA

Sl.No. :

IP. No/OP/No. :

Name :

Age /Sex :

Presenting complaint :

Defective vision Re/Le-Duration.

H/o Presenting Illness :

Past History :

H/o Ocular surgery

H/o Wearing spectacles

H/o Contact lens wear

H/o Dm/TB/HT

Family History :

Personal History :

General Examination :

Local Examination :

1. Head Posture

2. Facial Symmetry

3. Visual axes

Slit lamp examination

	RE	LE
Lids		
Conjunctiva		
Cornea		
Anterior chamber		
Iris		
Pupil		
Lens		
UCVA		
Distance:		
Near:		

Refraction:

BCVA

IOP

Fundus

Keratometry

Topography

KEY TO MASTER CHART

M $\longrightarrow$ male

F $\longrightarrow$ female

RE $\longrightarrow$ Right eye

LE $\longrightarrow$ left eye

D $\longrightarrow$ Dioptre

cyl $\longrightarrow$ cylinder

WTR $\longrightarrow$ with the rule

ATR $\longrightarrow$ Against the rule

K_f $\longrightarrow$ flatter axis

K_s $\longrightarrow$ Steeper axis

MASTER CHART

Serial Number	Name		Sex	Op No	Right Eye				Left Eye			
					K_s	K_f	Cyl	axis	K_s	K_f	Cyl	ax
1	amudha	28	f	39209					43.8	42.32	1.48	
2	anuradha	38	f	41954	43.77	42.91	0.86	11				
3	amudha	38	f	37109	44.91	44.44	0.47	166	44.9	44.29	0.61	
4	amulu	60	f	41994					45.29	44.34	0.95	
5	sara	57	f	65431	46.33	45.65	0.68	135	46.44	46.04	0.4	
6	iyyanar	63	m	43218	42.84	42.28	0.56	111	43.51	42.76	0.75	
7	bharati	26	f	46120	46.04	45.08	0.96	97	43.49	42.99	0.5	
8	bharath	37	m	23348	45.68	44.37	1.32	96	45.02	44.02	1	
9	christi priya	22	f	60411	45.59	44.1	1.5	80	44.2	43.09	1.01	
10	umadevi	23	f	23411	44.69	43.34	1.35	94	44.47	43.43	1.05	
11	dhanalakshmi	35	f	22610	44.29	43.26	1.03	98	42.63	41.63	1	
12	edwin	40	m	40908				101	42.88	42.48	0.4	
13	elumalai	39	m	44790	45.38	45.02	0.36	72	45.38	44.89	0.49	
14	ezhil	35	m	58370	43.98	42.49	1.49	101	44.08	43.02	1.06	
15	gajavalli	28	f	63086	44.56	43.73	0.84	174				
16	ganesan	36	m	61042	45.6	45.03	1.57	96	46.57	44.39	2.18	
17	gnanamani	63	f	63093	45.21	44.9	0.31	6	45.05	44.75	0.3	
18	deivam	70	m	68342	46.41	46.03	0.38	6				
19	gowri	24	f	37522				87	46.9	45.43	1.47	
20	indumati	22	f	40987				87	43.5	43.2	0.3	
21	rajamma	64	f	67544	47.04	46.75	0.29	169				
22	indrani	36	f	31260	45.81	44.64	1.16	107	45.41	43.41	2	
23	jaya	40	f	27118	46.02	43.72	1.3	89	45.86	45.29	0.57	
24	jyadeepan	21	m	58168	45.88	42.88	3	98	46	42.42	3.5	
25	kumar	32	m	67461	43.8	43.46	0.34	100				
26	naidu	68	m	69276	47.74	46.79	1.08	6				
27	kalimmal	68	f	63822	46.89	45.99	0.9	156				
28	kanniama	68	f	47711	45.78	44.24	1.54	169				
29	marriappan	70	m	67020	46.76	45.62	1.14	177				
30	vellakanni	61	f	27180	45.83	45.47	0.36	0				
31	kadhar	40	m	26883	45.34	44.7	0.64	7				
32	kusalkumari	36	f	29373	44.6	42.72	1.88	90	44.42	42.87	1.55	

Serial Number	Name		Sex	Op No	Right Eye				Left Eye			
					K_s	K_f	Cyl	axis	K_s	K_f	Cyl	ax
33	kumaresan	39	m	50201	45.88	45.12	0.76	101	45.96	45.33	0.63	
34	lakshmi	40	f	51231	43.99	42.98	1.01	101	43.69	42.4	1.29	
35	lokanayaki	38	f	41620	43.85	43.03	0.83	98	43.98	43.09	0.89	
36	mohan	45	m	42341	45.9	45.5	0.44	108				
37	mani	39	m	50269	45.36	43.76	1.6	83				
38	narasia	70	m	402068					46.64	46.21	0.43	
39	marriama	68	f	41139					48.49	47.48	1.02	
40	manniama	62	f	43682	46.87	45.92	0.95	76				
41	leela	63	f	43312	47.3	45.75	1.55	1	48.08	46.89	1.19	
42	muthulakshmi	52	f	23123	45.58	45.24	0.34	98	45.55	45.89	0.34	
43	muthuselve	48	f	43211	45.43	43.67	0.76	106				
44	shanti	38	f		44.49	43.04	1.45	83	44.85	43.71	0.74	
45	paramman	72	m	43078	48.99	47.73	1.26	24	48.01	46.99	1.02	
46	pughuzhali	52	f	43210	45.36	45.04	0.32	38	44.91	45.77	0.86	
47	pushpa	50	f	41201	47.04	46.24	0.8	109	47.23	46.45	0.78	
48	pyari	62	f	43121					46.2	45.72	0.49	
49	sarala	58	f	31221	46.81	46.21	0.59	129	46.02	45.27	0.75	
50	ramji	32	m	43105					42.75	42.32	0.44	
51	natesan	79	m	23132	46.35	45.8	0.65	3	46.92	46.12	0.8	
52	raganadhan	72	m	23121	46.4	45.77	0.63	169				
53	paranjothi	70	m	35498	46.35	45.43	0.92	162				
54	rayappan	68	m	24791	46.19	45.31	0.88	13				
55	rani	62	f	32965	48.28	45.96	2.33	4	47.68	46.2	1.47	
56	saraswati	64	f	23175	47.49	47.08	0.41	176	46.89	46.32	0.57	
57	sharmila	38	f	24718	44.62	43.71	0.9	68				
58	siraj	28	m	23178					44.5	43.88	0.62	
59	suba	23	f	37612					39.39	35.35	1.04	
60	victor	38	m	43781					44.54	44.08	0.46	
61	sugantha	68	f	44285	46.41	45.78	0.63	1	46	44.89	1.1	
62	shanti	62	f	47351					47.33	46.17	1.16	
63	papa	68	f	43613	46.53	46.07	0.45	6	46.2	45.96	0.24	
64	sasirekha	29	f	42165	42.47	41.45	0.92	100	45.33	43.1	1.23	
65	shankar	28	m	32781	42.23	41.6	0.43	87	43.16	41.25	0.91	

Serial Number	Name		Sex	Op No	Right Eye				Left Eye			
					K_s	K_f	Cyl	axis	K_s	K_f	Cyl	ax
66	shalini	20	f	45109	42.64	41.91	0.73	80				
67	shoba	28	f	32745	43.24	42.19	1.06	89	43.37	42.91	0.46	
68	swaroopa	26	f	34181	41.04	40.03	1.01	96	42.6	41.6	1	
69	vanitha	24	f	34165	42.85	42.19	0.66	97	42.99	42.12	0.86	
70	venketraj	26	m	36712	44.02	43.12	0.9	94	44.75	43.6	1.15	
71	umadevi	26	f	42185	43.81	42.23	1.58	97	44.79	43.04	1.76	
72	swati	24	f	34813	44.18	42.67	1.51	100	44.04	42.61	1.43	
73	shanti	36	f	43163	44.79	44.08	0.71	98	44.7	43.5	1.2	
74	nivaskumar	22	m	43816	44.27	43.11	1.16	79	44.49	42.97	1.52	
75	peter	26	m	43981	43.13	42.43	0.7	82				
76	ponmalar	25	m	41291	45.42	44.95	0.47	78	44.17	43.58	0.5	
77	prakasan	38	m	43819	42.97	42.62	0.36	96	43.62	43.1	0.52	
78	selve	21	f	41291	40.21	39.33	0.88	87				
79	rajalaksmi	23	f	45183	43.74	42.27	1.47	87	43.12	41.07	1.07	
80	rajina	28	f	45184	43.12	42.45	0.67	96	42.92	43.42	0.5	
81	rupa	36	f	43291	45.99	45.25	0.74	104	46.9	46.5	0.4	
82	roshan	25	f	31672	44.22	43.49	0.73	94	44.11	43.18	0.14	
83	devani	70		21376	47.93	46.6	1.33	89	45.37	44.77	0.61	
84	stalin	61	m	23458	43.85	41.87	1.98	87				
85	sami	62	f	23781	42.39	41.67	0.72	118				
86	savithri	66	f	28134	45.64	45.12	0.51	149				
87	panchali	70	f	23712	45.53	44.44	1.09	187	45.64	46.39	0.75	
88	ramaniaamal	68	f	26184	47.68	46.2	1.47	169	47.15	45.68	1.47	
89	tilagam	62	f	23109	45.98	45.37	0.61	160	45.77	44.77	1	
90	tirupati	72	f	27315	46.19	45.49	0.7	173	46.02	45.52	0.5	
91	mangalam	62	f	43017	46.9	45.43	1.47	175	45.7	45.14	0.56	
92	dasaradhan	72	f	42754	45.05	44.75	0.3	6	46.57	45.72	0.75	
93	mangamma	67	f	43162	46.79	45.77	1.02	189	46.02	45.22	0.8	
94	jayalakmi	62	f	43982	46.12	45.62	0.5	3	46.39	45.8	0.59	
95	pandurangan	64	m	31627	46.95	46.35	0.6	18	47.7	46.2	0.5	
96	lalitham	61	f	34195	46.19	45.49	0.7	173	46.64	46.04	0.6	
97	saroja	65	f	49828	46.17	45.58	0.5	172	46.12	45.09	1.03	
98	sarasu	69	f	42859	47.45	47.23	0.78	162	47.02	46.52	0.5	

Serial Number	Name		Sex	Op No	Right Eye				Left Eye			
					K_s	K_f	Cyl	axis	K_s	K_f	Cyl	ax
99	thirivegadam	70	m	35207	47.31	46.92	0.39	172	47.48	46.98	0.5	
100	manonmani	64	f	37591	46.62	4612	0.5	4	46.35	45.82	0.63	
101	ganga ye	65	f	43612	46.15	45.4	0.75	150				
102	purushothaman	65	m	31020	45.31	44.94	0.36	138				
104	puroshathaman	65	m	34518	47.02	46.22	0.8	172	47.23	46.32	0.91	
105	domadaran	65	m	37162	46.91	45.89	1.02	167	46.52	46.02	0.5	
106	pankajammal	62	f		46.74	45.82	0.92	6	47.09	46.34		
107	rasti	70	f	45317	46.92	46.12	0.8	173	48	46.8	1.2	
108	sundarimmal	69	f	43178	47.52	47.02	0.5	8	46.87	46.12	0.75	
109	rajan	60	m	393890					46.78	46.39	0.39	
109	mouthu	65	m	40920	48.01	46.89	1.12	121	46.75	46.25	1.5	
110	vasnthakumari	59	f	393871					46.22	45.35	0.87	
111	perumal	52	m	394130					45.81	46.66	0.79	
112	jaythnbe	54	f	395123					46.45	46.02	0.43	
113	kathiresan	60	m	395632	46.31	46.91	0.6	101	45.78	45.21	0.57	
114	rahim	56	m	39602	46.7	46.02	0.68	7	47.04	45.54	1.5	
115	lakshmi	54	f	395860	46.3	45.75	0.55	180	46.02	44.98	1.03	
116	savithri	52	f	39652	46.63	45.91	0.72	4				
117	periyanayagam	60	m	396316	46.39	45.98	0.41	180	46.28	46.58	0.38	
118	natesan	60	m	392979	47.09	46.34	0.75	87	47.09	46.08	1.02	
119	joseph	56	m	392546	46.74	45.95	0.9	3	46.22	45.42	0.8	
120	lailabee	52	m	394908	46.91	45.89	1.02	78	46.52	47.02	0.5	
121	baby	60	m	395425	46.89	45.7	1.19	173	46.12	45.62	0.5	
122	rajeshwari	59	m	395855	46.13	45.61	0.52	4	46.39	45.5	0.89	
123	gnanamal	55	m	393006	47.28	46.48	0.8	41	47.32	46.34	0.98	
124	thotiamma	52	m	393428	46.33	45.31	1.02	29	45.86	46.68	0.62	
125	rajendran	60	m	394130	47.23	46.32	0.91	42	47.5	46.48	1.02	
126	balammal	58	m	34915	46.29	45.89	0.4	138	45.75	45.25	0.5	
127	fathima	59	m	395855	46.24	45.44	0.8	60				
128	kalyani	44	m	365428	46.02	45.27	0.45	136				
129	govindhamal	55	m	34339					47.45	46.99	0.46	
130	kesavan	55	m	393888	46.72	45.84	0.88	140				
131	sakunthala	49	f	394138	47.33	46.97	0.36	35				

Serial Number	Name		Sex	Op No	Right Eye				Left Eye			
					K_s	K_f	Cyl	axis	K_s	K_f	Cyl	a
132	parvatham	54	f	395298					47.3	46.8	0.5	
133	seetha	55	f	395631	47.91	46.72	0.38	44				
134	jamuna	44	f	396311	47.8	46.9	0.9	144				
135	sunderaaswaran	60	m	395866	45.89	45.16	0.73	76	46.73	45.71	1.02	
136	suseela	56	f	396107	47.36	46.57	0.79	170	46.93	45.92	1.01	
137	murthy	54	m	396586	47.2	46.41	0.79	14	47.53	46.81	0.72	
138	munisekhar	48	m	396603	47.44	46.95	0.53	12	47.07	46.18	0.89	
139	saroja	46	f	396615	47.72	46.91	0.81	80	46.9	46.12	0.78	
140	raniamma	56	f	396304	46.2	45.42	0.78	4	46.42	45.16	0.36	
141	adhimoolam	45	m	396294	47.19	46.63	0.56	110	46.89	46.08	0.82	
142	saraswati	58	f	393621	46.55	46.11	0.44	101				
143	bhuvaneshavari	42	f	394874	46.66	45.91	0.75	90				
144	chellama	55	f	395147	47.5	45.89	0.61	96				
145	thiruvasagam	50	m	395451								
146	kathirseslvan	42	m	396103					46.12	45.3	0.82	
147	narayanan	44	m	396108					46.19	45.69	0.5	
148	perumal	52	m	394882					47.03	46	1.03	
149	kannamal	48	f	395136					46.5	45.38	1.12	
150	gnanamal	57	f	395847					47.21	46.12	1.09	
151	ananadan	47	m	395875					47.5	46.56	0.94	
152	ethiraj	41	m	39630	46.91	46.13	0.78	97	45.2	44.39	0.81	

LIST OF SURGERIES PERFORMED

Sl.No.	Name	Age / Sex	OP / IP No.	Diagnosis	Surgery Performed
1	Mrs. Muniamma	65 / F	41447	RE - Aphakia LE - MC	LE - ECCE with PCIOL
2	Mrs. Jayalakshmi	62/F	38233	RE - MC LE - IMC	LE - ECCE with PCIOL
3	Mrs. Logammal	80/F	382591	BE - MC	LE - ECCE with PCIOL
4	Mr. Vadivel	65 / M	382805	RE - MC LE - IMC	LE - ECCE with PCIOL
5	Mrs. Subbammal	60/F	383102	RE - IMC LE - MC	LE - ECCE with PCIOL
6	Mr. James	63 / M	383595	BE - PCC	LE - ECCE with PCIOL
7	Mr. Hameed	53/ M	391020	BE - IMC	RE - ECCE with PCIOL
8	Mr. Muthu	71/M	384442	RE - MC LE - IMC	RE - ECCE with PCIOL
9	Mr. Pethaya	40 / M	394862	RE -MC LE - IMC	RE - ECCE with PCIOL
10	Mrs. Thengammal	55 / F	384012	RE - IMC LE - MC	LE - ECCE with PCIOL
11	Mrs. Dhanabakiyam	70 / F	385999	RE - Aphakia LE - Nuclear Cataract	LE - ECCE with PCIOL
12	Mr. Engayya	58/ M	16840	RE - MC LE - IMC	RE - ECCE with PCIOL
13	Mrs. Muniammal	63 / F	32624	BE - IMC	RE - ECCE with PCIOL
14	Mr. Chitubabu	60 / M	389924	RE - Aphakia LE - MC	LE - ECCE with PCIOL
15	Mrs. Maragadham	50 / F	390453	RE - Pseudophakia LE - MC	LE - ECCE with PCIOL

Sl.No.	Name	Age / Sex	OP / IP No.	Diagnosis	Surgery Performed
16	Mrs. Meena	60 / F	39028	BE - IMC	LE - ECCE with PCIOL
17	Mr. Chinnadurai	65/ M	390736	RE- Pseudophakia LE - MC	LE - ECCE with PCIOL
18	Mrs. Salmabee	80 / F	390986	RE - IMC LE - Aphakia	LE - ECCE with PCIOL
19	Mr. Manickam	65 / M	390947	RE- Pseudophakia LE - MC	LE - ECCE with PCIOL
20	Mrs. Meera	75 / F	398469	BE - Nuclear Cataract	RE - SICS with PCIOL
21	Mrs. Meenakshi	65/ F	390462	RE - MC LE - IMC	RE - SICS with PCIOL
22	Mr. Hari	56 / M	395787	RE - HMC LE - MC	RE - SICS with PCIOL
23	Mr. Rajendran	63 / M	394565	BE - IMC	RE - SICS with PCIOL
24	Mr. Ravindran	70 / M	395324	BE - HMC	RE - SICS with PCIOL
25	Mr. Ashok	25 / M	32651	RE - Chalazion	RE - I & C
26	Mrs. Rajammal	40 / F	406219	BE - Nasal pterygium	RE - pterygium excision
27.	Mrs. Muniammal	60 / F	40251	LE - Chronic dacryocystitis	LE - DCT
28	Mrs. Rajammal	68/ F	45385	RE - Chronic dacryocystitis	RE - DCT
29	Mrs. Lakshmi	62 / F	49261	LE - Chronic dacryocystitis	LE - DCR
30	Mr. Samuvel	35 / M	357231	RE - Scleral tear with iris prolapse	RE - Scleral tear suturing done
31	Mr. Rajesh	40 / M	24156	RE - Corneal tear	RE - Corneal tear suturing

Sl.No.	**Name**	**Age / Sex**	**OP / IP No.**	**Diagnosis**	**Surgery Performed**
					done

BE - Both Eye
RE - Right Eye
LE - Left Eye
IMC - Immature Cataract
MC - Mature Cataract
HMC - Hyper Mature Cataract
ECCE - Extra Capsular Cataract Extraction
PCIOL- Posterior Chamber Intra Ocular Lens
SICS - Small Incision Cataract Surgery
DCT - Dacryocystectomy
DCR - Dacryocystorhinostomy
I & C - Incision and Curettage